

CLAIMS

What is claimed is:

1. A well plate comprising:
 - a plurality of wells, each well being defined by at least one surface that defines a cavity having an opening, wherein each well comprises:
 - at least one aperture through the at least one surface of the well, the aperture configured to provide a gas supply access to the interior of the well; and
 - at least one of a pH level sensor and a dissolved oxygen sensor disposed within the well.
2. The well plate of Claim 1, wherein each well is defined by a bottom surface and at least one side surface that defines the opening.
3. The well plate of Claim 1, wherein the at least one of a pH level sensor and a dissolved oxygen sensor comprises a fluorescent material disposed on the interior of the at least one surface of the well.
4. The well plate of Claim 3, wherein each well is defined by a bottom surface and at least one side surface and wherein the at least one of a pH level sensor and a dissolved oxygen sensor are disposed on the interior of the bottom surface of the well.
5. The well plate of Claim 1, wherein the at least one of a pH level sensor and a dissolved oxygen sensor comprise at least one probe that is coupled to the interior of the well.
6. The well plate of Claim 5, further comprising a lid configured to be placed over the plurality of wells, wherein the at least one probe extends from the lid into the interior of the well.
7. The well plate of Claim 1, further comprising at least one membrane coupled to the at least one surface of each well and covering the at least one aperture.

8. The well plate of Claim 7, wherein each well is defined by a bottom surface and at least one side surface and the at least one membrane is coupled to the bottom surface of each well.

9. The well plate of Claim 7, wherein the membrane is formed from a gas permeable material.

10. The well plate of Claim 7, wherein the membrane is formed from a porous material with pores less than 0.2 μ m.

11. The well plate of Claim 7, wherein a plurality of membranes is used with each well.

12. The well plate of Claim 1, wherein each well comprises a plurality of apertures through the at least one surface of the well, the plurality of apertures configured to provide a gas supply access to the interior of the well.

13. The well plate of Claim 1, wherein each well comprises an array of apertures through the at least one surface of the well, the array of apertures configured to provide a gas supply access to the interior of the well, wherein each aperture in the array is approximately 0.2 mm to 1 mm in diameter.

14. The well plate of Claim 1, wherein each well further comprises:

a second aperture through the at least one surface of the well, the second aperture configured to place a temperature control element in thermal contact with the interior of the well; and

a third aperture through the at least one surface of the well, the third aperture configured to place a temperature measurement element in thermal contact with the interior of the well.

15. The well plate of Claim 1, wherein the at least one surface of each well has a first thickness, wherein each well further comprises an indentation in the at least one surface of the well, the indentation have a second thickness that is less than the first thickness.

16. The well plate of Claim 15, wherein each well further comprises a thermally conductive material within the indentation.

17. The well plate of Claim 15, further comprising a first membrane coupled to the at least one surface of each well and covering the at least one aperture and a second membrane coupled to the at least one surface of each well and covering at least one of the second and third apertures.

18. The well plate of Claim 15, further comprising a membrane coupled to the at least one surface of each well and covering the at least one aperture and the second and third apertures, the membrane having a first thickness over the at least one aperture and having a second thickness over the second and third apertures, the second thickness being greater than the first thickness.

19. A well plate comprising:

- a plurality of wells, each well having at least one surface that defines an opening at a top of the well, wherein each well comprises:

- a first aperture through the at least one surface of the well, the first aperture configured to provide a gas supply access to the interior of the well; and
 - at least one additional aperture through the at least one surface of the well, the at least one additional aperture configured to place one of a temperature control element and a temperature measurement element in thermal contact with the interior of the well.

20. The well plate of Claim 19, wherein the at least one additional aperture through the at least one surface of the well comprises:

- a second aperture through one of the surfaces of the well, the second aperture configured to place a temperature measurement element in thermal contact with the interior of the well; and

a third aperture through one of the surfaces of the well, the third aperture configured to place a temperature control element in thermal contact with the interior of the well.

21. The well plate of Claim 19, wherein the first aperture and the at least one additional aperture are through a bottom surface of each well.

22. The well plate of Claim 19, wherein each the first aperture is one of a plurality of apertures through the at least one surface of the well that are configured to provide a gas supply access to the interior of the well.

23. The well plate of Claim 22, wherein the plurality of apertures form an array of apertures, wherein each aperture in the array is approximately 0.2 mm to 1 mm in diameter.

24. The well plate of Claim 19, wherein the first aperture comprises a plurality of supporting ribs extending across the first aperture.

25. The well plate of Claim 19, wherein each well further comprises a means for sensing at least one of the pH level and dissolved oxygen within the well.

26. The well plate of Claim 25, wherein the means for sensing comprises one or more fluorescent materials disposed on the bottom interior surface of the well.

27. The well plate of Claim 25, wherein the means for sensing comprises at least one probe that extends into the interior of each well.

28. The well plate of Claim 27, the well plate further comprising a lid configured to be placed over the wells, wherein the at least one probe extends from the lid into the interior of the well.

29. The well plate of Claim 19, wherein each well further comprises at least one membrane coupled to the at least one surface of the well and covering at least the first aperture.

30. The well plate of Claim 19, further comprising a first membrane coupled to the at least one surface of each well and covering the first aperture and a second membrane coupled to the at least one surface of each well and covering the at least one additional aperture.

31. The well plate of Claim 19, further comprising a membrane coupled to the at least one surface of each well and covering the first aperture and the at least one additional aperture, the membrane having a first thickness over the first aperture and having a second thickness over the at least one additional aperture, the second thickness being greater than the first thickness.

32. An apparatus for controlling at least one of the pH level and dissolved oxygen in a plurality of wells in a well plate, each well being defined by at least one surface that defines an opening and has an aperture, the apparatus comprising:

- a gas supply for providing gas to a well through the aperture in the well;
- a detector for detecting one of the pH level and dissolved oxygen in the contents of a well; and
- a control system coupled to the gas supply and the detector, the control system controlling the amount of gas supplied to the well by the gas supply in response to the one the pH level and dissolved oxygen detected by the detector.

33. The apparatus of Claim 32, further comprising:

- at least one gasket for providing a seal with at least one well in the well plate, the gasket having at least one aperture associated with each well, wherein the gas supply provides gas through the through the aperture in the gasket.

34. The apparatus of Claim 32, the gas supply comprising:

- a gas input;
- a plurality of gas lines coupled to the gas input, wherein there is at least one gas line associated with each well in the well plate; and

at least one valve coupled to each gas line and the control system and is controlled by the control system to control the flow of gas through the gas line.

35. The apparatus of Claim 34, wherein the detector detects the pH level in the contents of the well, and the gas input is coupled to receive one of CO₂ and NH₃.

36. The apparatus of Claim 34, wherein detector detects the dissolved oxygen in the contents of the well, and the gas input is coupled to receive one of oxygen and compressed air.

37. The apparatus of Claim 34, wherein the gas supply comprises:

a plurality of gas inputs; and

a valve associated with each gas input on each of the plurality of gas lines, wherein each valve is controlled by the control system.

38. The apparatus of Claim 37, wherein the detector detects the pH level in the contents of the well, and wherein a first gas input is coupled to receive CO₂ and a second gas input is coupled to receive NH₃.

39. The apparatus of Claim 37, wherein the detector detects the pH level in the contents of the well and the apparatus further comprises a second detector for detecting the dissolved oxygen in the contents of the well, wherein a first gas input is coupled to receive one of CO₂ and NH₃ and a second gas input is coupled to receive one of oxygen and compressed air.

40. The apparatus of Claim 37, wherein the detector detects the pH level in the contents of the well and the apparatus further comprises a second detector for detecting the dissolved oxygen in the contents of the well, wherein a first gas input is coupled to receive CO₂, a second gas input is coupled to receive NH₃ and a third gas input is coupled to receive one of oxygen and compressed air.

41. The apparatus of Claim 32, wherein each well in the well plate includes at least one fluorescent material disposed within the well, the at least one fluorescent material reacts to one of the pH level and dissolved oxygen in the contents of the well, the detector comprising:

- a light source configured to illuminate the fluorescent material; and
- a photodetector for detecting the light emitted by the fluorescent material.

42. The apparatus of Claim 41, wherein the light source illuminates the fluorescent material at a frequency and wherein detector measures the phase delay of the light emitted by the fluorescent material.

43. The apparatus of Claim 41, the detector comprising a first plurality of optical fibers coupled to the light source, each optical fiber in the first plurality of optical fibers illuminates the fluorescent material in an associated well and a second plurality of optical fibers coupled to the photodetector, each optical fiber in the second plurality of optical fibers configured to receive the light emitted by the fluorescent material in an associated well.

44. The apparatus of Claim 43, the detector further comprising a first multiplexer disposed between the light source and the first plurality of optical fibers and a second multiplexer disposed between the photodetector and the second plurality of optical fibers.

45. The apparatus of Claim 41, wherein the light source and photodetector are mounted on a two dimensional stage, the two dimensional stage configured to move the light source and photodetector to illuminate the fluorescent material and detect the light emitted by the fluorescent material in each well in the well plate.

46. The apparatus of Claim 41, wherein the detector comprises a plurality of light sources, each light source configured to illuminate the fluorescent material in an associated well and a plurality of photodetectors, each photodetector configured to detect the light emitted by the fluorescent material in an associated well.

47. The apparatus of Claim 32, wherein the detector comprises a probe that extends into the well.

48. The apparatus of Claim 32, the apparatus further comprising:
a plurality of temperature control elements, each temperature control element configured to be in thermal contact with the interior of an associated well; and
a plurality of temperature measurement elements, each temperature measurement element configured to be in thermal contact with the interior of an associated well;
a temperature control system coupled to each temperature control element and to each temperature measurement element, wherein the temperature control system independently controls the temperature of the temperature control element for each well based on the temperature measured by the temperature measurement element for the same well.

49. The apparatus of Claim 32, wherein the gas supply is coupled to receive one of hydrogen, methane, and an inert gas.

50. An apparatus used with a well plate that has a plurality of wells, each well being defined by at least one surface that defines an interior cavity having an opening, the apparatus comprising:

a plurality of drip valves, wherein there is at least one drip valve associated with each well positioned over the opening of each well, the drip valves configured to provide a liquid to the interior cavities of the associated wells;

a plurality of detectors for detecting a property of the contents of the wells, wherein there is at least one detector associated with each well; and

a control system coupled to the plurality of detectors and the plurality of drip valves, the control system controlling the amount of the liquid provided by the drip valves to the associated wells in response to the property of the contents in the associated wells detected by the detectors associated with each well.

51. The apparatus of Claim 50, wherein the liquid is one of NaOH and acid.

52. The apparatus of Claim 50, further comprising a gas supply for providing gas to the interior cavities of the associated wells, wherein the control system is coupled to the gas supply, the control system controlling the amount of gas provided by the gas supply to the associated wells in response to the property of the contents in the associated wells detected by the detectors associated with each well.

53. The apparatus of Claim 50, wherein each well in the well plate includes at least one fluorescent material disposed within the well, the at least one fluorescent material reacts to the property of the contents of the well, wherein the plurality of detectors comprise:

- at least one light source configured to illuminate the fluorescent material; and
- at least one photodetector for detecting the light emitted by the fluorescent material.

54. The apparatus of Claim 50, wherein the light source illuminates the fluorescent material at a frequency and wherein detector measures the phase delay of the light emitted by the fluorescent material.

55. The apparatus of Claim 50, wherein the plurality of detectors comprises at least one probe that extends into the interior cavity of the well.

56. A method comprising:

- providing a well plate with a plurality of wells with content in each well;
- measuring at least one of the pH level and the dissolved oxygen in the contents of each well; and
- providing at least one gas to the contents of at least one well through a membrane and an aperture in the well in response to the measured at least one the pH level and dissolved oxygen.

57. The method of Claim 56, further comprising:

- measuring the temperature of the contents of each well; and

independently controlling the temperature of the contents of a plurality of wells based on the measured temperature of the contents in each well.

58. The method of Claim 56, wherein measuring least one of the pH level and the dissolved oxygen in the contents of each well is performed optically.

59. The method of Claim 56, wherein providing at least one gas comprises independently controlling the gas supply to each well.

60. The method of Claim 56, wherein providing at least one gas comprises providing at least one of CO₂, and NH₃ to alter the pH level of the contents in a well and providing at least one of oxygen and compressed air to alter the dissolved oxygen level in the contents of the well.

61. The method of Claim 56, wherein measuring at least one of the pH level and the dissolved oxygen in the contents of each well comprises periodically illuminating a fluorescent material in each well and measuring the phase delay of the light emitted by the fluorescent material.